

REMARKS/ARGUMENTS

The Telephone Interview of February 25, 2005

Applicant, Michael F. Robinson, and his undersigned attorney, David N. Slone, wish to thank the Examiner, Matthew A. Anderson, for the courtesies and attention during the telephone interview held February 25, 2004. Also present by telephone were Michael Lord, a European patent attorney of the British firm Gill Jennings & Every, and James Dixon, a director of EMF Ireland Limited, the assignee of the present application. The interview lasted approximately one hour.

During the interview, the parties discussed the prior art over which the claims stand rejected (Ishizumi, Oki, and McNerney) and the distinctions over the prior art. In particular, Applicant noted that the present invention provides for very efficient growth and use of precursor materials. By separately heating first and second precursors to separate temperatures at which the precursors decompose to generate species, each precursor can be heated to a temperature that promotes efficient cracking.

As discussed, efficient cracking, while extremely valuable, is not enough, because the species can undergo undesirable reactions after the decomposition. For example, nitrogen atoms produced by cracking ammonia will recombine to form nitrogen molecules and be of no value to the growth process if the atoms are allowed to remain in their atomic state for too long. However, by cracking the precursors close to the substrate, the invention reduces the time for recombination or combination with other materials that they encounter. Moreover, by providing the cracked species separately and sequentially to the substrate, the invention reduces premature combination of the species before they reach the substrate.

Applicant explained that the claimed invention, which provides these advantages, would not have been obvious in view of the prior art. Once explained, after the fact, the benefits and results may seem natural, but the patent law does not allow an obviousness rejection based on hindsight reconstruction. The benefits exceeded expectations. During the interview Applicant described experiments performed at Simon Fraser University in British Columbia

where the techniques of the invention were applied to produce aluminum nitride, a notoriously difficult material, with relative ease.

No draft claims were presented, and no agreement was reached. However, the Examiner suggested that Applicant amend the claims to more fully set forth the manner in which the benefits are achieved, and it is believed that this Amendment is responsive to the Examiner's suggestions.

The Claimed Invention Distinguishes over the Prior Art

Applicant has amended the independent claims to more clearly recite the separate heating of the first and second precursors to respective different first and second temperatures, emphasizing that the separate heating of each precursor causes efficient decomposition and that the decomposition at or adjacent the substrate reduces the time period in which unfavourable reactions can occur.

Claim 30 has been amended to eliminate a limitation which, had it been left in the claim, would have made the amended claim redundant with dependent claim 22 in view of the amendment to claim 16. Claim 30 has further been amended to recite that the first temperature is a temperature which is a suitable growth temperature for the material, and the first heating means is also used to heat the substrate to a temperature generally equal to the first temperature.

Support for the additional claim language regarding the efficient decomposition and the reduced time for unfavorable reactions can be found at page 2, lines 9-27, which read as follows:

In contrast to the known methods, we separately heat the precursors to their respective decomposition temperatures at or adjacent this region, the region constituting a growth region in which the species combine. In this way, each precursor can be heated to its most efficient decomposition (cracking) temperature, while carrying out this process adjacent to the region minimises the risk of nascent atoms recombining before reaching the substrate surface.

The species formed by the decomposition of the precursors are highly reactive and rapidly form more stable products. The probability of a species being involved in further reactions is a function of time and concentration. By decomposing the precursors in the vicinity of the growth region, the species formed are encouraged to combine at the growth region on the substrate, rather than forming undesirable reaction products. The decomposition of the precursors in close proximity to the growth region reduces the time period in which unfavourable reactions can occur.

Similarly, support for the additional claim language regarding the suitable growth temperature can be found at page 6, lines 1-8, which read as follows:

The substrate carrier 3 is heated such that the substrate 1 and the substrate support 2 are also heated due to their proximity to the substrate carrier 3 attaining a suitable growth temperature for the substrate 1 i.e. a temperature at which the precursor 5 introduced through the inlet 6 will most efficiently crack. A suitable temperature for the growth of GaN is in the range 600-800°C.

Accordingly, the amendment to the claims does not add new matter.

The claims define the invention, and the following discussion should be taken in that context. If the Examiner feels that these remarks are inconsistent with the claims as construed by the Examiner, Applicant welcomes further input from the Examiner.

The beneficial effect of the invention is caused by the "holistic" combination of three different factors, all of which are recited in all the independent claims. These are:

- a) The separate heating of the precursors to their respective (efficient) decomposition temperatures;
- b) The provision of the decomposition "at or adjacent" the substrate such that the species produced by at least one of the decomposition reactions are able to reach the substrate without taking part in a unfavourable reactions along the way; and
- c) The separate and sequential supply of these species to the substrate which again prevents unwanted reactions and therefore provides a high quality product using a mono-epitaxy mechanism.

Applicant respectfully submits that this combination is nowhere disclosed or suggested by the prior art.

The invention provides extra degrees of freedom for processing different materials. For example, if one of the precursors decomposes efficiently at the same temperature as the growth temperature, there is no need to heat the substrate to a different temperature than the decomposition temperature for that precursor. On the other hand, if the material grows efficiently at a different temperature to the efficient decomposition temperatures of the precursors, separate provision can be made to maintain the substrate at the suitable growth temperature. Claims 1 and 16 are generic to both these cases. Amended claim 30 addresses the first case where the substrate is heated to generally the same temperature as one of the

precursors. New dependent claims 31 and 32 address the second case, reciting maintaining the substrate at a third temperature that is different from the first and second temperatures.

Further, decomposing the precursors at or adjacent the substrate provides additional capability for those cases where the species are atoms which are prone to recombination. The invention does not require that the materials being deposited require the generation of atomic species, but is readily adaptable to such applications, and suitably configured can produce high purity materials efficiently and also produce materials, heretofore difficult to produce outside the laboratory, with industrial viability.

Therefore, it is respectfully submitted that the independent claims are allowable over the prior art. As discussed in previous USPTO communications, Ishizumi and Oki illustrate two *mutually exclusive* methods of depositing semi-conductor materials, namely Metal Organic Vapour Phase Epitaxy (MOVPE) as described in Oki, and Atomic Layer Epitaxy (ALE) as described in Ishizumi. The MOVPE approach relies upon the mixing of precursors in the gaseous phase above the substrate. In contrast, ALE requires that there is no such mixing and rather that the species are supplied to the substrate individually.

Applicant respectfully submits that that the references cannot be readily combined, except in hindsight. While Oki discloses a separate heater for one of the precursors, Oki requires the *mixing* of gases above the substrate. Thus Oki provides no guidance of how to provide a second heater to Ishizumi which has a moving baffle to maintain the two gases separated. U.S. Patent No. 6,143,082 to McInerney et al. is cited for optimizing temperatures during processing. Applicant does not believe that M McInerney's teachings provide any suggestion to combine the other references, nor do they disclose or suggest the claimed invention.

Therefore, it is respectfully submitted that the claims, especially as amended set forth a patentable advance over the prior art.

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Reply to Office Action mailed September 28, 2004

PATENT

CONCLUSION

In view of the foregoing, Applicants believe all claims now pending in this Application are in condition for allowance and an action to that end is respectfully requested.

If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at 650-326-2400.

Respectfully submitted,

A handwritten signature in black ink that reads "David Slone". The signature is written in a cursive, flowing style.

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